Thermal Signature of Subsurface Fluid Flow in the Dixie Valley Geothermal Field, Nevada

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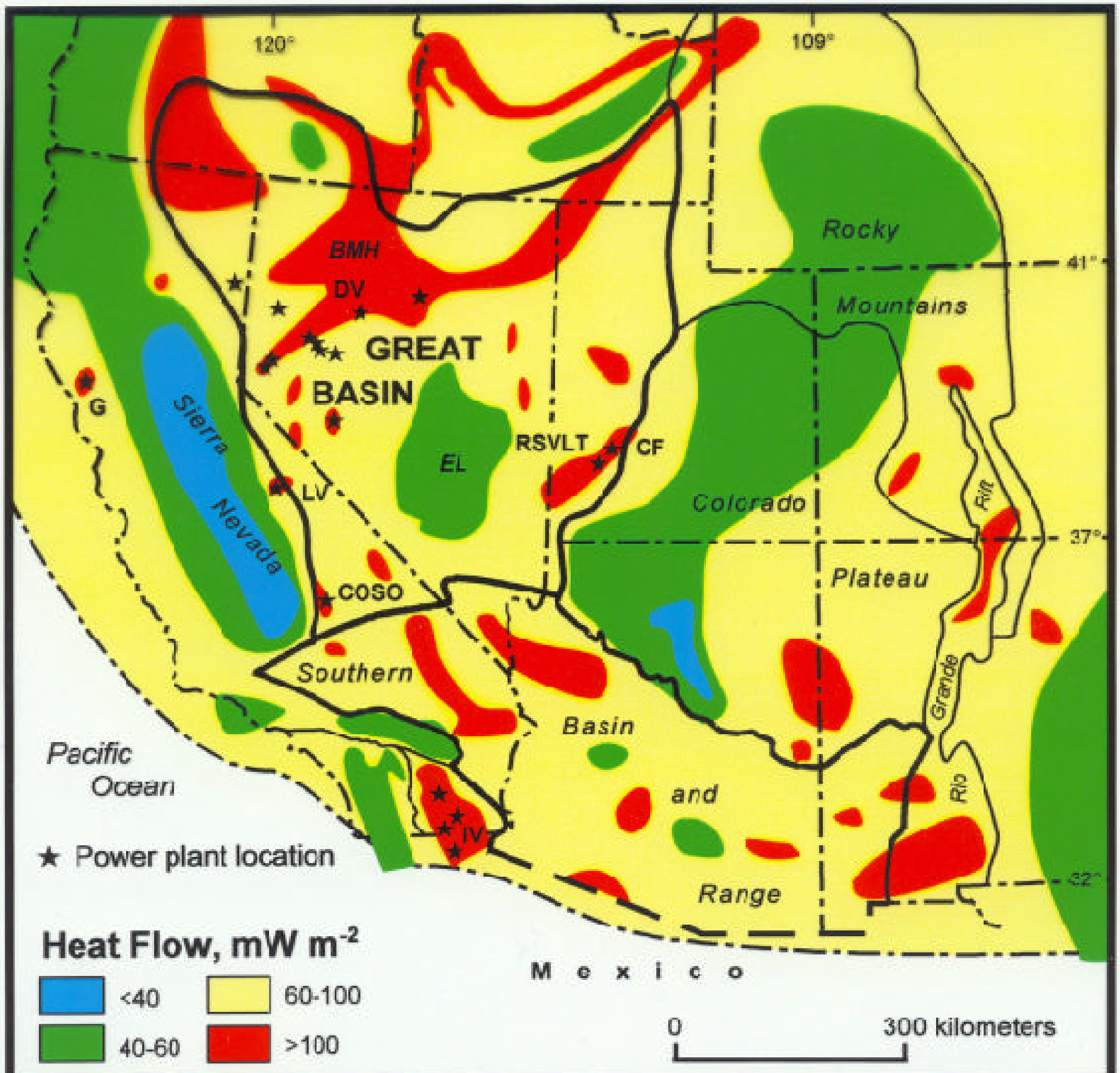
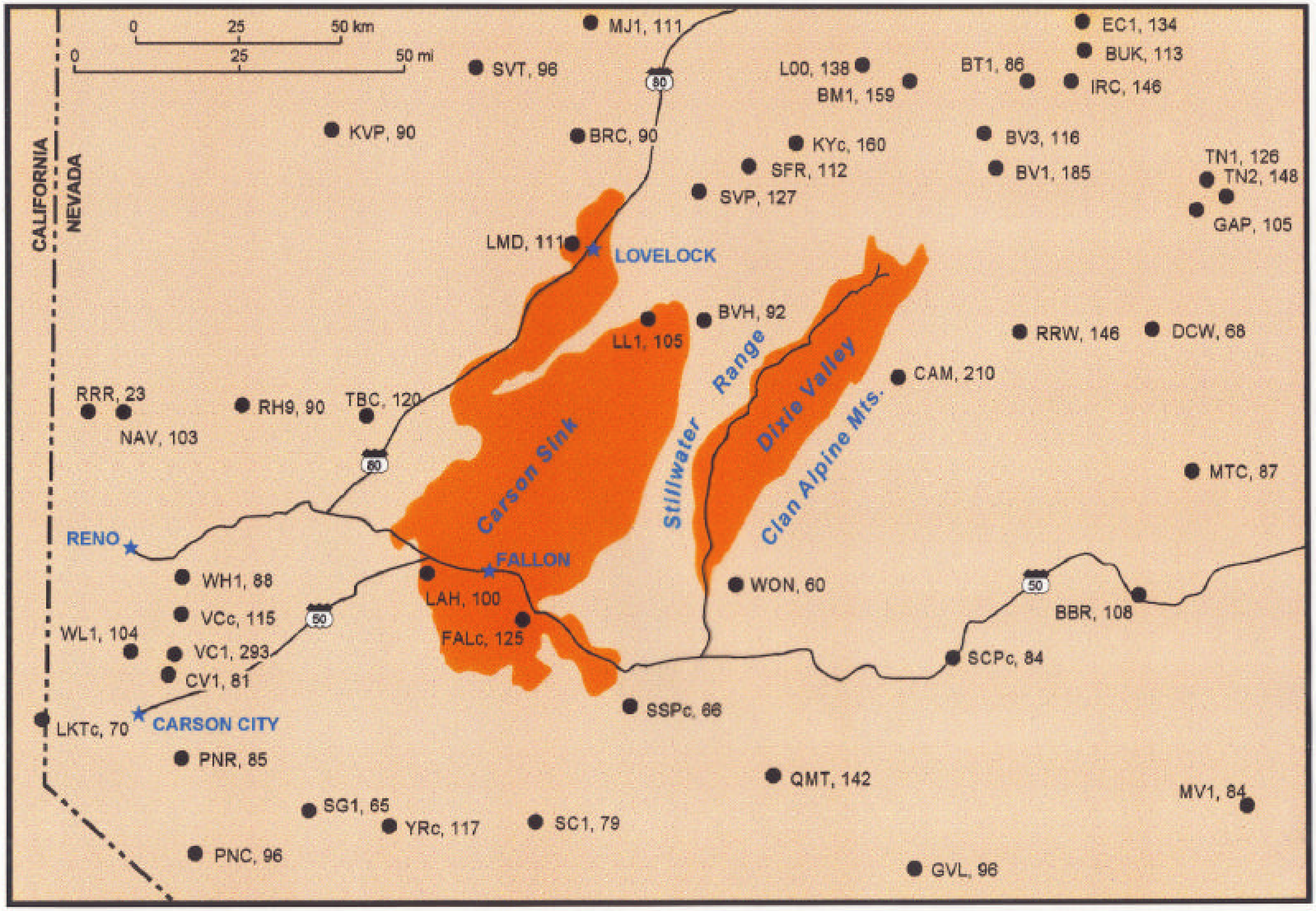
Outline

1. Introduction – What, Where, Why
2. Data
3. Thermal Effects of Wellbore Flow
4. Thermal Effects of Flow up the SFZ
5. Seismic Evidence of Deep Crustal Thermal Conditions
6. Conclusions and Suggestions for Future Work

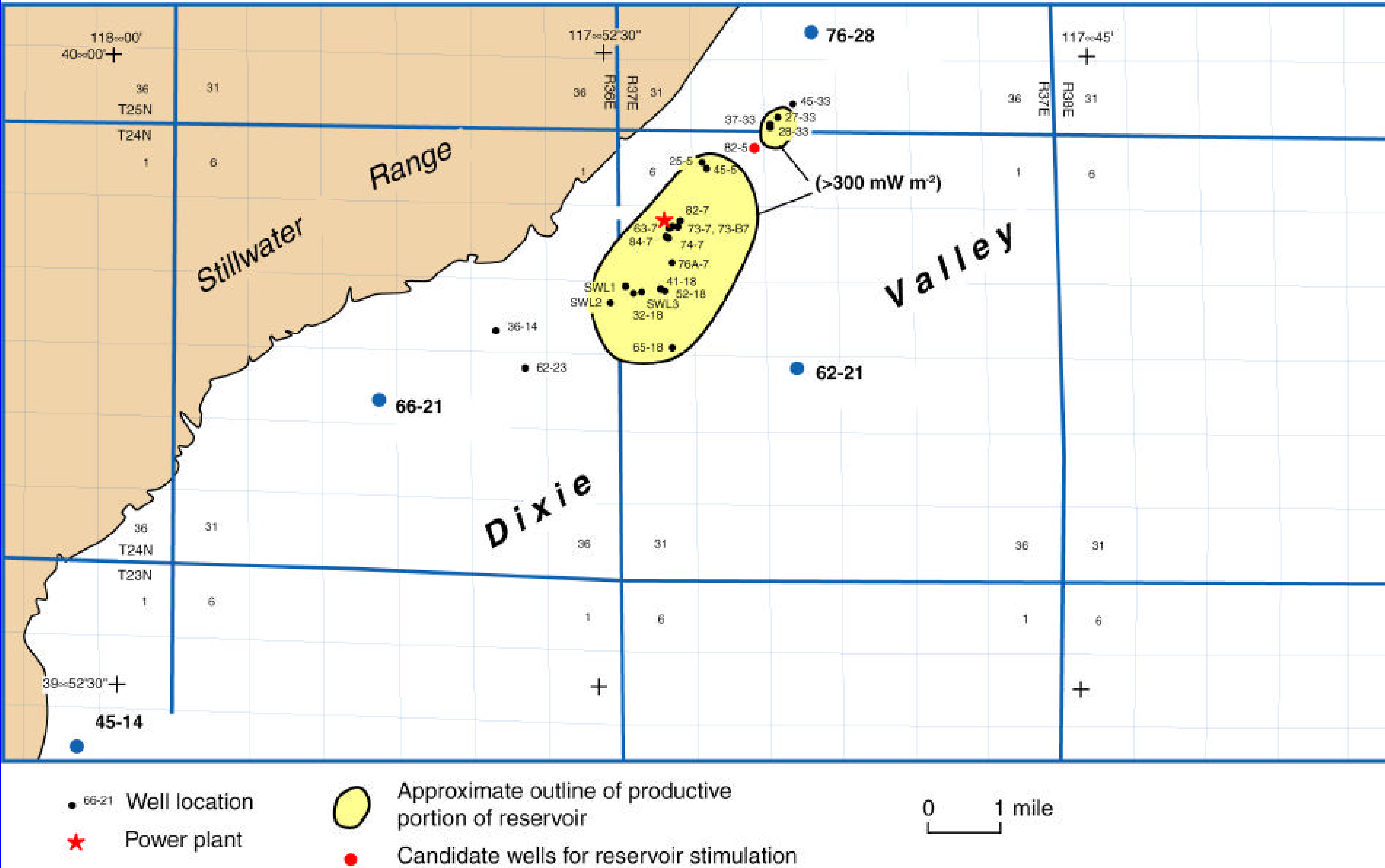


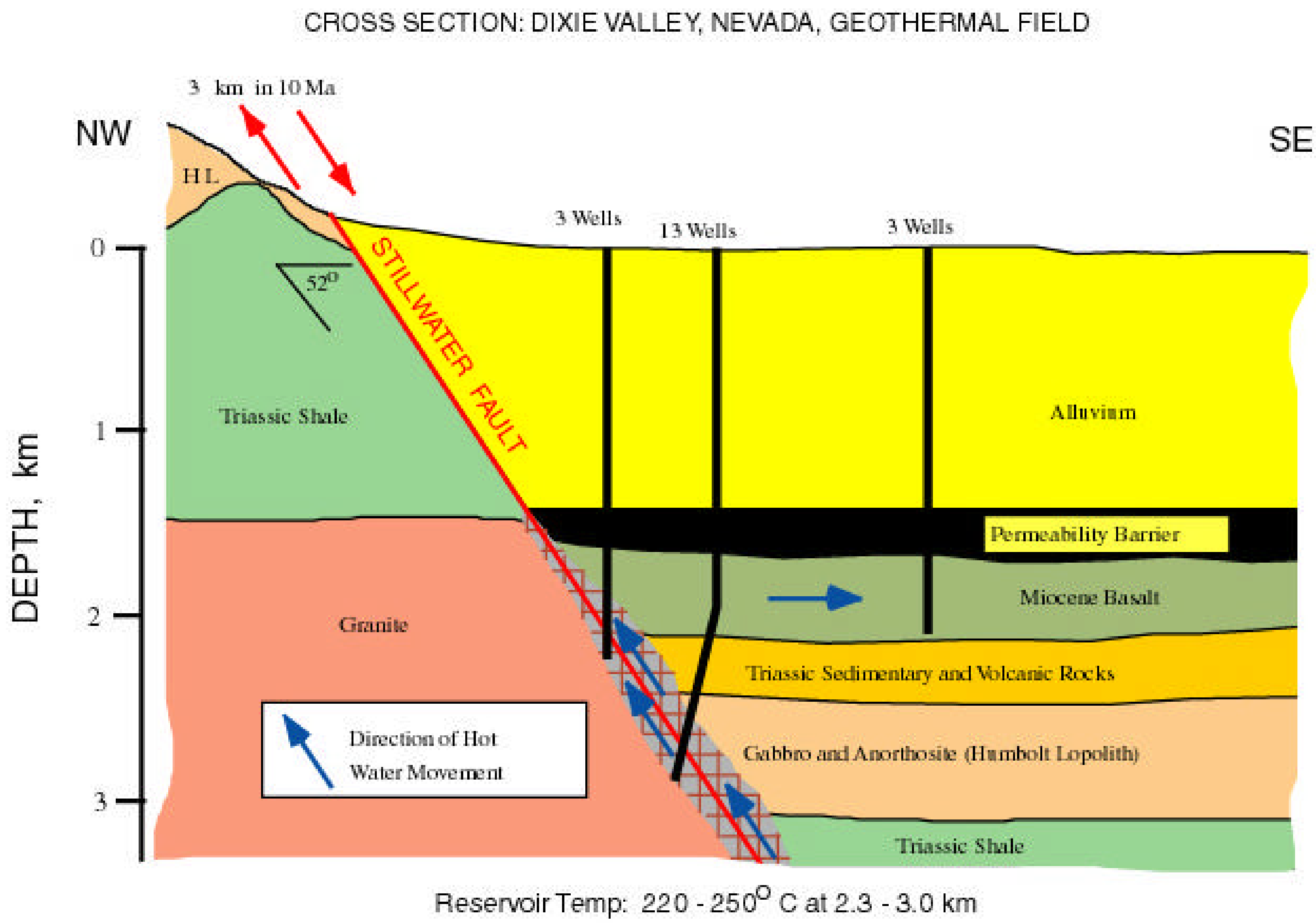
120°
109°
41°
37°
32°
BMH
DV
GREAT
BASIN
G
Sierra
Nevada
LV
EL
RSVLT
CF
COSO
Rocky
Mountains
Colorado
Plateau
Rift
Grande
Rio
Southern
Basin
and
Range
Pacific
Ocean
IV
★ Power plant location
Heat Flow, mW m-2
<40
40-60
60-100
>100
Mexico
0
300 kilometers

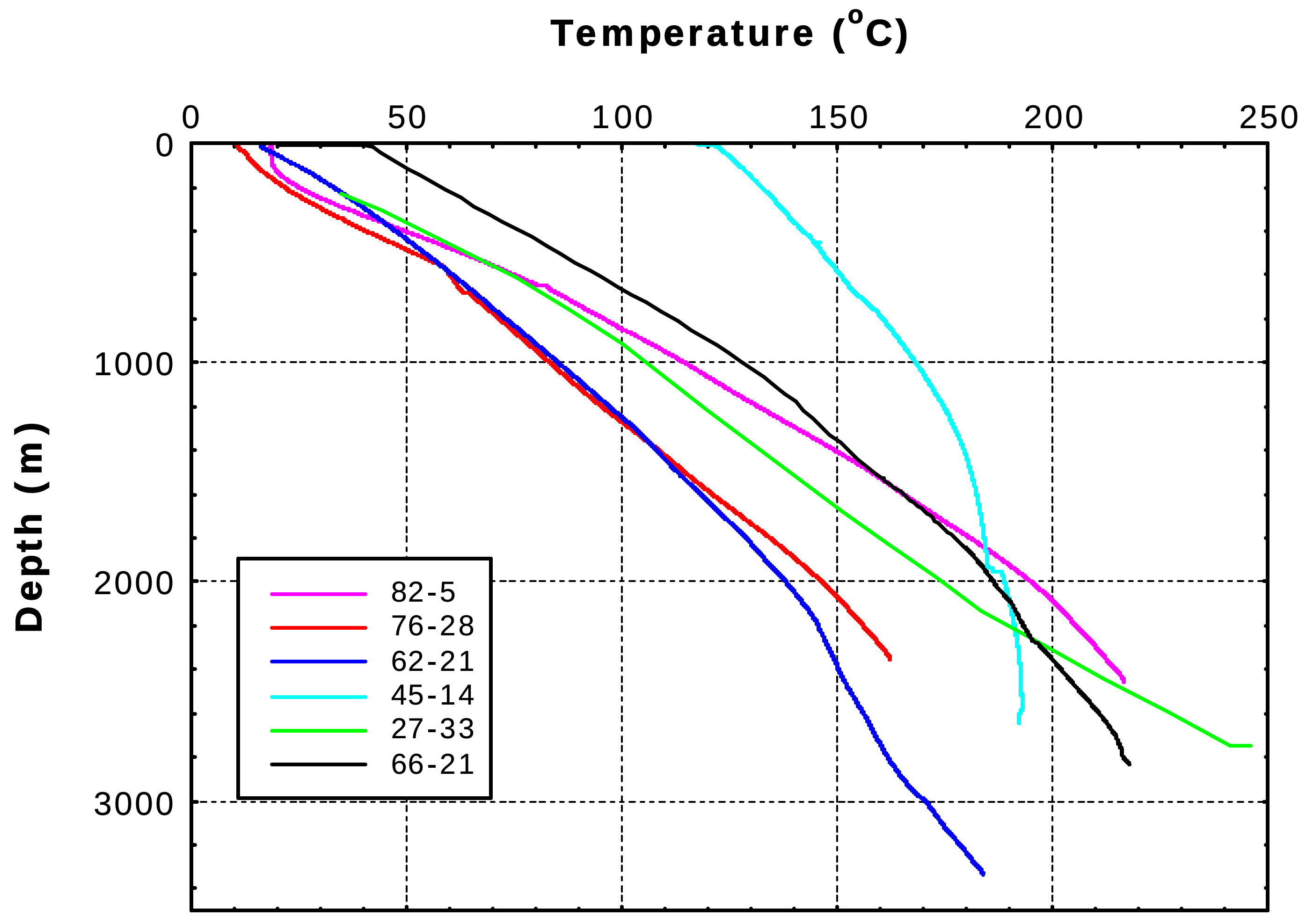


Heat Flow from Basement Rocks in the Dixie Valley Region

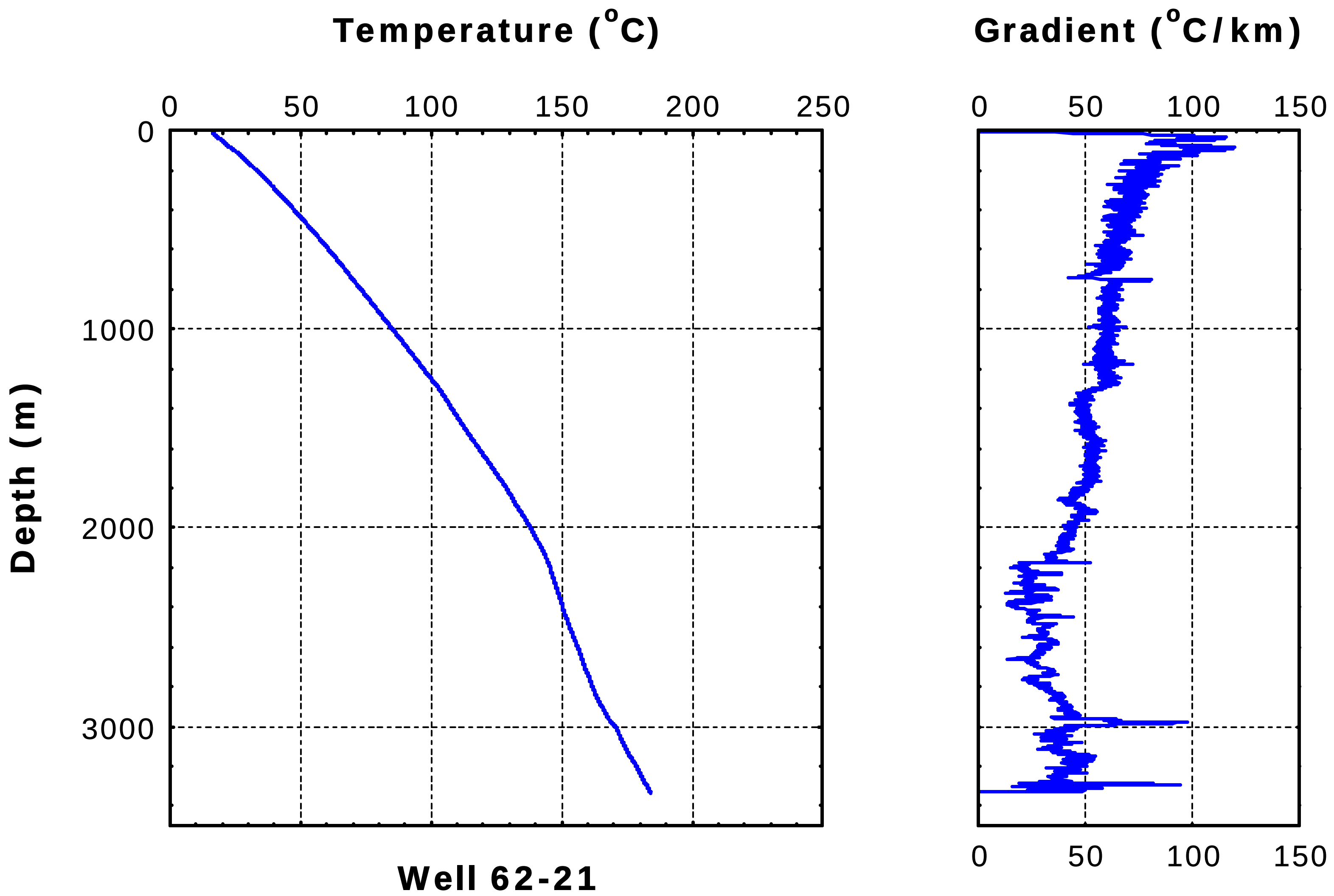
Heat Flow in Dixie Valley



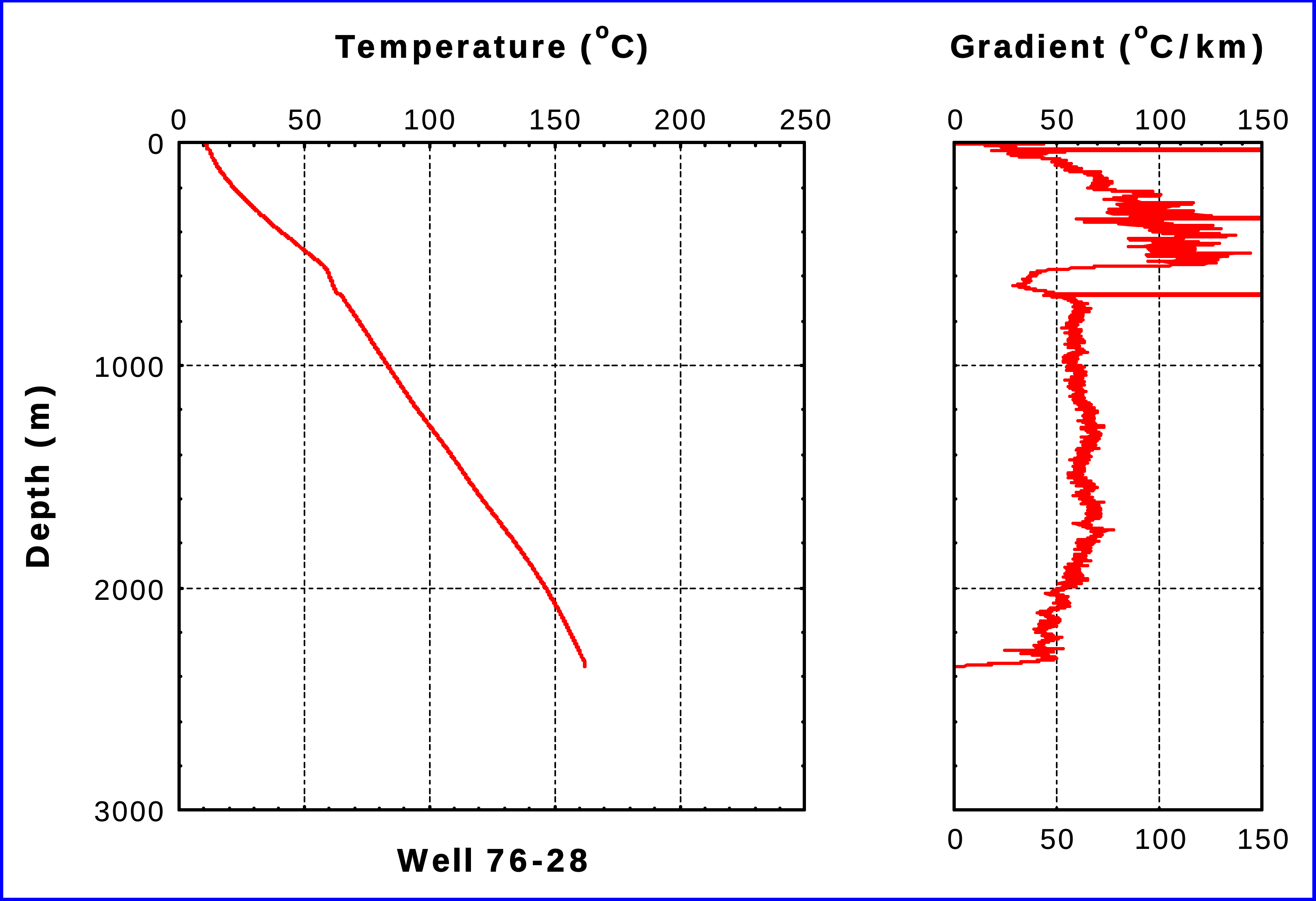

CROSS SECTION: DIXIE VALLEY, NEVADA, GEOTHERMAL FIELD
3 km in 10 Ma
NW
SE
H L
3 Wells
13 Wells
3 Wells
0
1
2
3
DEPTH, km
52°
STILLWATER FAULT
Triassic Shale
Alluvium
Permeability Barrier
Miocene Basalt
Granite
Triassic Sedimentary and Volcanic Rocks
Direction of Hot Water Movement
Gabbro and Anorthosite (Humbolt Lopolith)
Triassic Shale
Reservoir Temp: 220 - 250° C at 2.3 - 3.0 km

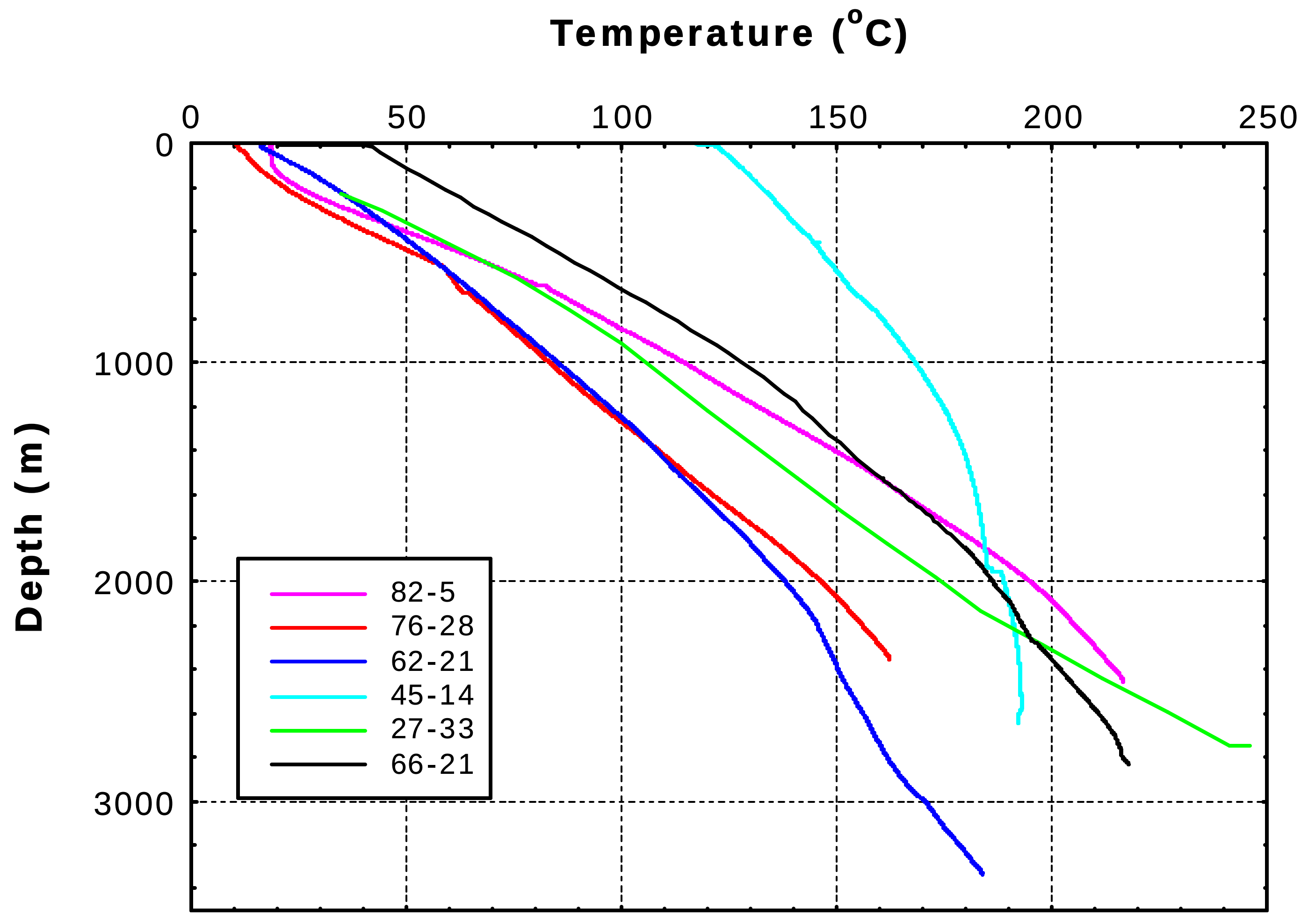


Temperature Profiles from Dixie Valley



Temperature (°C)
0
50
100
150
200
250
Gradient (°C/km)
0
50
100
150
Depth (m)
0
1000
2000
3000
Well 62-21


Temperature (^oC)
Gradient ($^oC/km$)
0
50
100
150
200
250
0
1000
2000
3000
Depth (m)
0
50
100
150
Well 76-28



Temperature Profiles from Dixie Valley

Ramey Model for Thermal Effects of Wellbore Flow

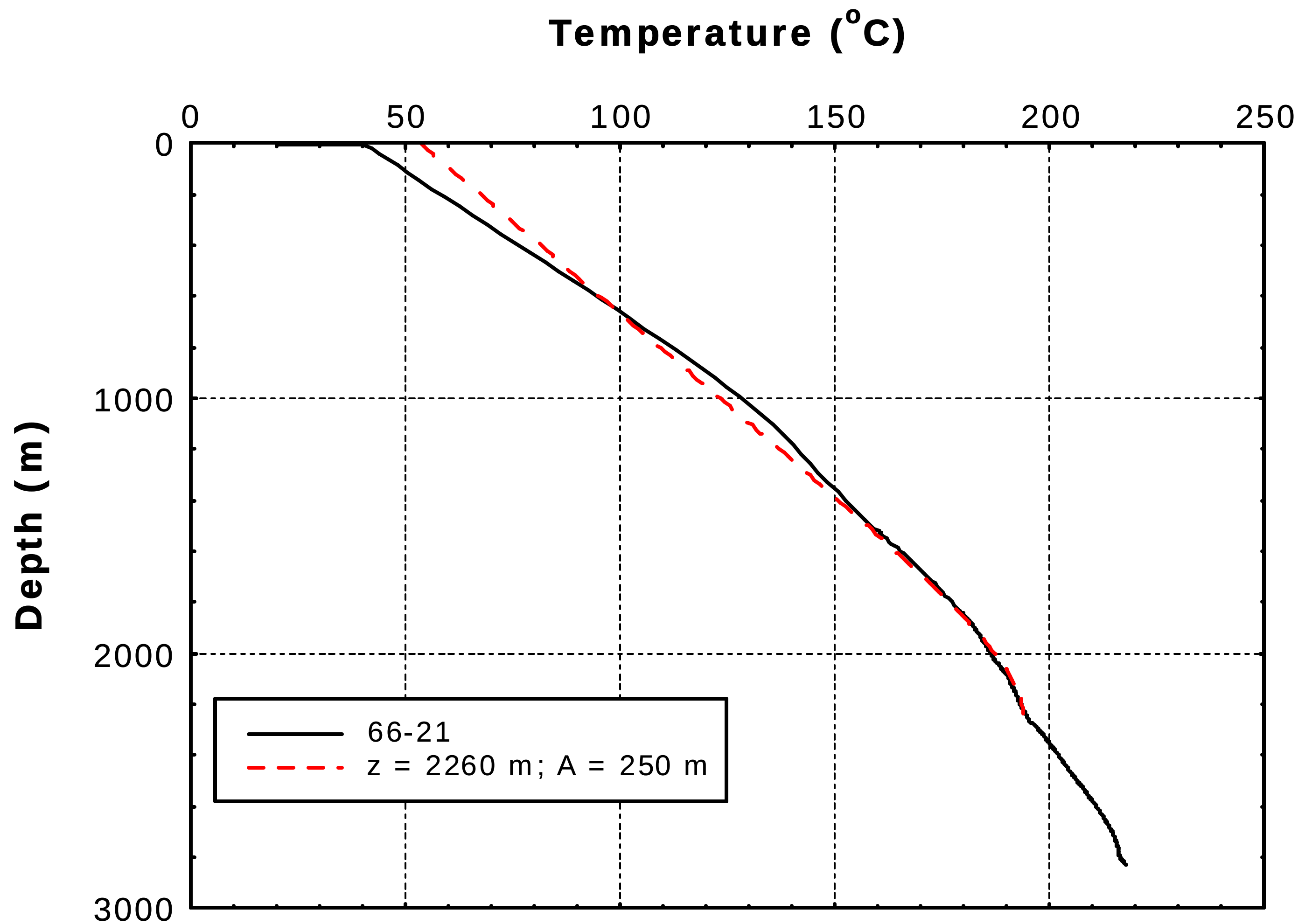
$$T(z) = T(0) + \Gamma \cdot (z - z_f) - (\exp((z - z_f)/A) - 1) \cdot \Gamma A$$

where

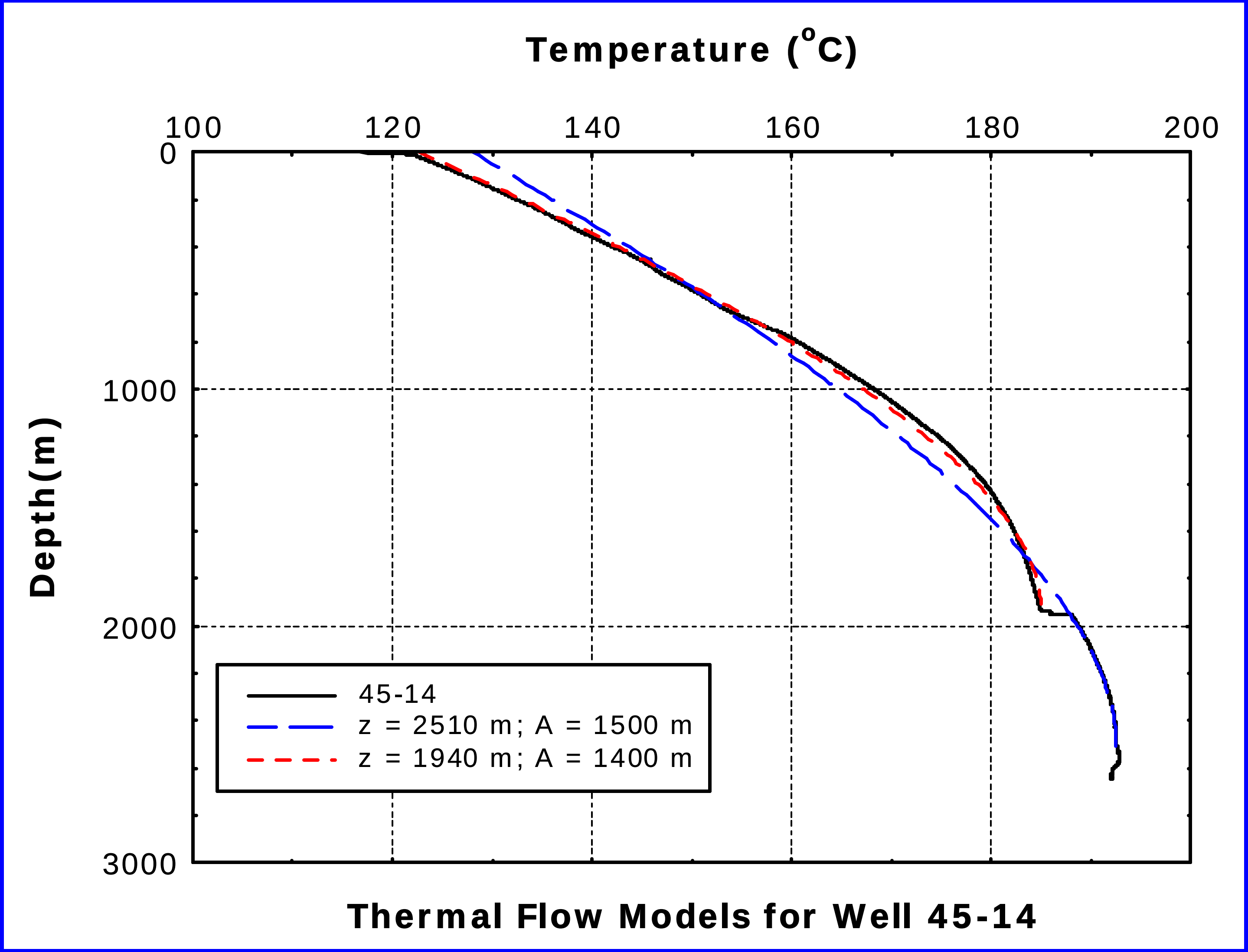
$$A = v r_f C\ r\ \ f(t)/2l$$

when $at/r^2 > 1000$ (weeks to months)

$$f(t) = -\ln(r/2\sqrt{at}) - 0.2885$$



Thermal Flow Model for Well 66-21



Temperature (°C)
100
120
140
160
180
200
0
1000
2000
3000
Depth(m)
45-14
z = 2510 m; A = 1500 m
z = 1940 m; A = 1400 m
Thermal Flow Models for Well 45-14

Results –

Estimated Flow Rates

Well 45-14 - ~1.1 liters/sec or 14 gpm

Well 66-21 - ~0.17 liters/sec or 2.5 gpm (1.8 gpm measured)

Estimated Heat Flow

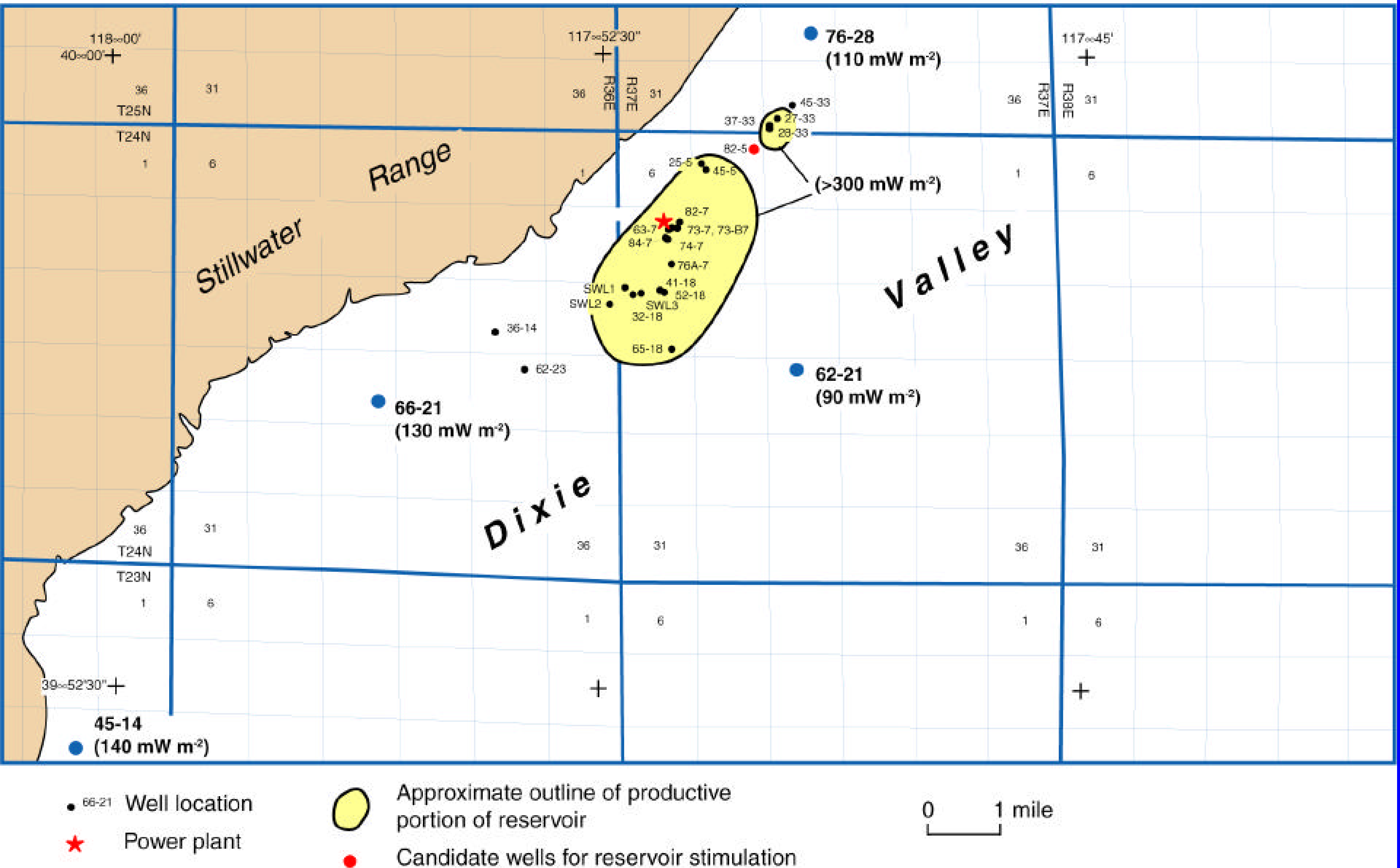
Well 62-21 - ~90 mWm^{-2}

Well 76-28 - ~110 mWm^{-2}

Well 45-14 - ~*140* mWm^{-2}

Well 66-21 - ~*130* mWm^{-2}

Heat Flow in Dixie Valley



For heat flow above an inclined fracture with upward flow

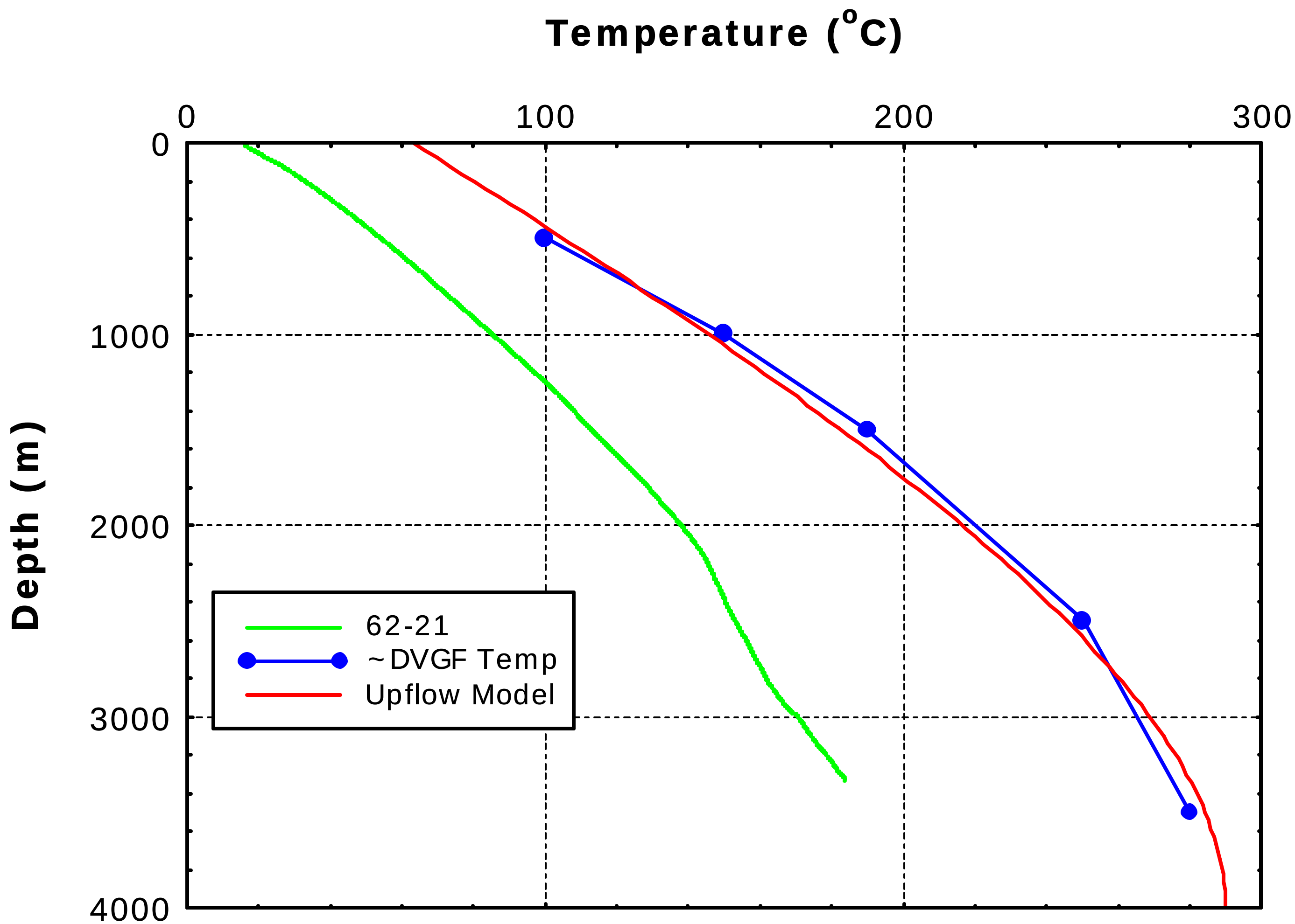
$$\Delta q = WC_f \Gamma \sin q$$

W=1.4-3.5 x 10^{-4} kgm^{-1}s^{-1}, which equates to 4.4 to 11 m^3/yr for each meter of fault length.

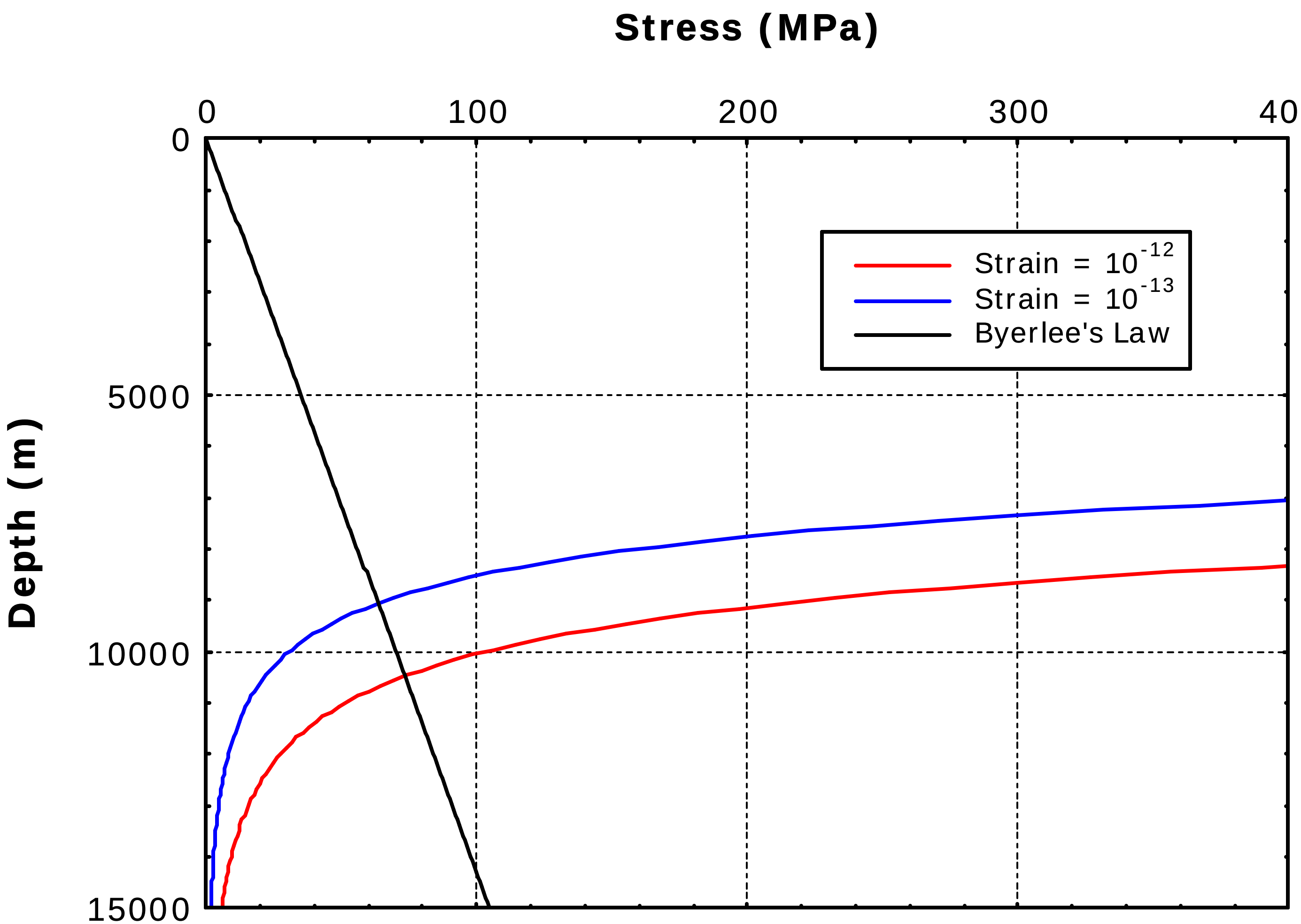
Within DVGF –

Q = 200 to >300 mWm^{-2}

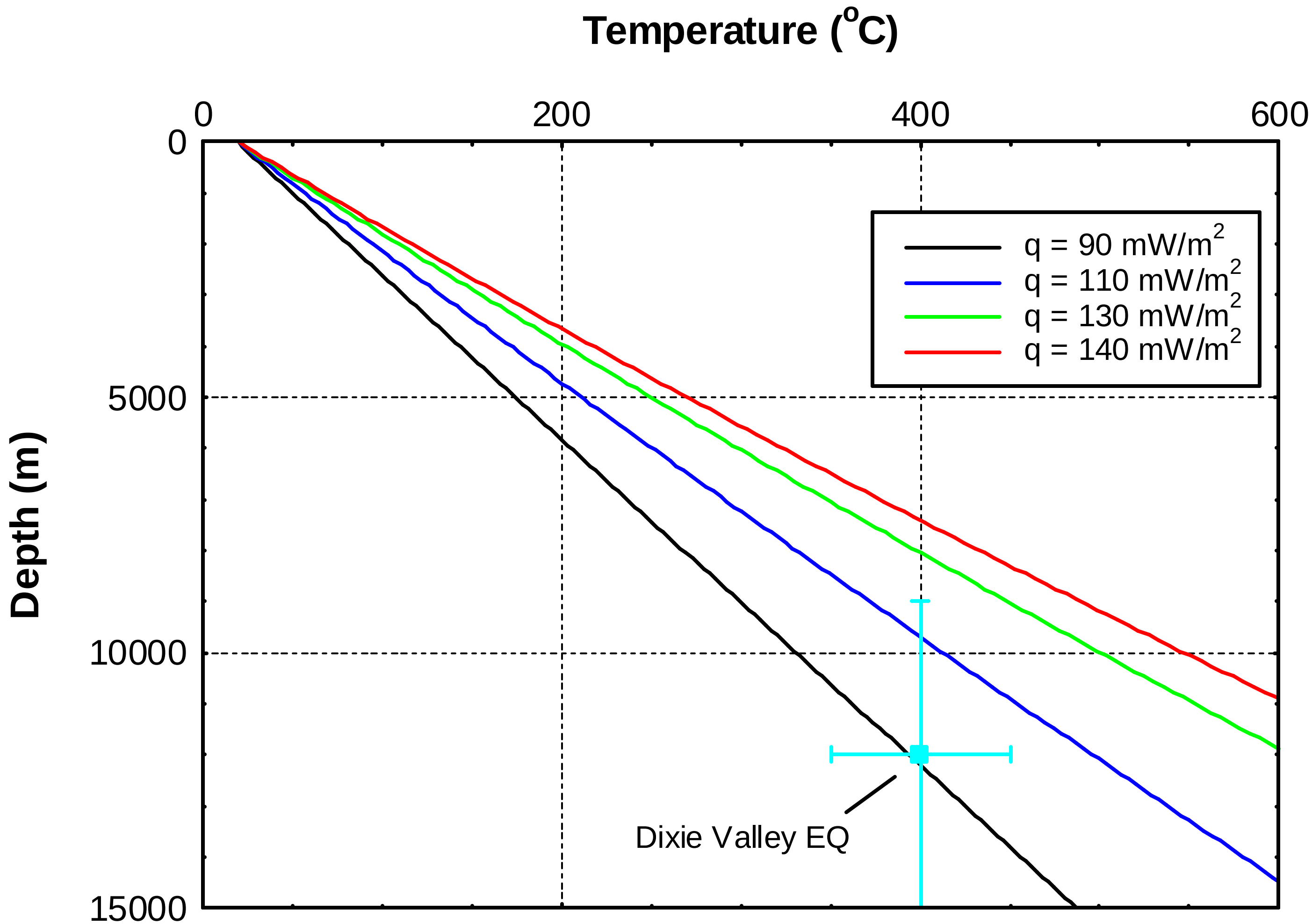
Upflow W = 23 to 46 m^3/yr



Dixie Valley Temperatures and Flow Model



Possible Strength Profiles for DV



Possible Geotherms for Dixie Valley Region

Conclusions

1. Flowing well temperatures can yield useful information on fluid entries and undisturbed gradients
2. Evidence for elevated temperatures and heat flow southwest of the DVGF (45-14, 66-21), but anomalies confined in extent
3. DVGF within BMH and historical seismicity to the south is consistent with high heat flow
4. If DVGF not associated with anomalous crustal thermal conditions, similar systems may be found elsewhere in BMH. Permeability is the key.